Appendix A

Modified Mercalli Intensity (MMI) Index Scale

Modified Mercalli (MM) Intensity Scale *

I. Not felt—or, except rarely under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt:
sometimes birds, animals, reported uneasy or disturbed;
sometimes dizziness or nausea experienced;
sometimes trees, structures, liquids, bodies of water, may sway—doors may swing, very slowly.

II. Felt indoors by few, especially on upper floors, or by sensitive or nervous persons.
Also, as in grade I, but often more noticeably:
sometimes hanging objects may swing, especially when delicately suspended;
sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly;
sometimes birds, animals, reported uneasy or disturbed;
sometimes dizziness or nausea experienced.

III. Felt indoors by several, motion usually rapid vibration.
Sometimes not recognized to be an earthquake at first.
Duration estimated in some cases.
Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away.
Hanging objects may swing slightly.
Movements may be appreciable on upper levels of tall structures.
Rocked standing motor cars slightly.

IV. Felt indoors by many, outdoors by few.
Awakened few, especially light sleepers.
Frightened no one, unless apprehensive from previous experience.
Vibration like that due to passing of heavy, or heavily loaded trucks.
Sensation like heavy body striking building, or falling of heavy objects inside.
Rattling of dishes, windows, doors; glassware and crockery clink and clash.
Creaking of walls, frame, especially in the upper range of this grade.
Hanging objects swung, in numerous instances.
Disturbed liquids in open vessels slightly.
Rocked standing motor cars noticeably.

V. Felt indoors by practically all, outdoors by many or most: outdoors direction estimated.
Awakened many, or most.
Frightened few—slight excitement, a few ran outdoors.
Buildings trembled throughout.
Broke dishes, glassware, to some extent.
Cracked windows—in some cases, but not generally.
Overturned vases, small or unstable objects, in many instances, with occasional fall.
Hanging objects, doors, swing generally or considerably.
Knocked pictures against walls, or swung them out of place.
Opened, or closed, doors, shutters, abruptly.
Pendulum clocks stopped, started, or ran fast, or slow.
Moved small objects, furnishings, the latter to slight extent.
Spilled liquids in small amounts from well-filled open containers.
Trees, bushes, shaken slightly.

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*Adapted from Sieberg's (1923) Mercalli-Cancani scale, modified and condensed. Quoted from Wood and Neumann (1931).

VI. Felt by all, indoors and outdoors.
Frightened many, excitement general, some alarm, many ran outdoors.
Awakened all.
Persons made to move unsteadily.
Trees, bushes, shaken slightly to moderately.
Liquid set in strong motion.
Small bells rang—church, chapel, school, etc.
Damage slight in poorly built buildings.
Fall of plaster in small amount.
Cracked plaster somewhat, especially fine cracks chimneys in some instances.
Broke dishes, glassware, in considerable quantity, also some windows.
Fall of knick-knacks, books, pictures.
Overturned furniture in many instances.
Moved furnishings of moderately heavy kind.

VII. Frightened all—general alarm, all ran outdoors.
Some, or many, found it difficult to stand.
Noticed by persons driving motor cars.
Trees and bushes shaken moderately to strongly.
Waves on ponds, lakes, and running water.
Water turbid from mud stirred up.
Incaving to some extent of sand or gravel stream banks.
Rang large church bells, etc.
Suspended objects made to quiver.
Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc.
Cracked chimneys to considerable extent, walls to some extent.
Fall of plaster in considerable to large amount, also some stucco.
Broke numerous windows, furniture to some extent.
Shook down loosened brickwork and tiles.
Broke weak chimneys at the roofline (sometimes damaging roofs).
Fall of cornices from towers and high buildings.
Dislodged bricks and stones.
Overturned heavy furniture, with damage from breaking.
Damage considerable to concrete irrigation ditches.

VIII. Fright general—alarm approaches panic.
Disturbed persons driving motor cars.
Trees shaken strongly—branches, trunks, broken off, especially palm trees.
Ejected sand and mud in small amounts.
Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters.
Damage slight in structures (brick) built especially to withstand earthquakes.
Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling.
Fall of walls.
Cracked, broke, solid stone walls seriously.
Wet ground to some extent, also ground on steep slopes.
Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers.
Moved conspicuously, overturned, very heavy furniture.

IX. Panic general.
Cracked ground conspicuously.
Damage considerable in (masonry) structures built especially to withstand earthquakes:
threw out of plumb some wood-frame houses built especially to withstand earthquakes;
great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames;
serious to reservoirs; underground pipes sometimes broken.

X. Cracked ground, especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks.
Landslides considerable from river banks and steep coasts.
Shifted sand and mud horizontally on beaches and flat land.
Changed level of water in wells.
Threw water on banks of canals, lakes, rivers, etc.
Damage serious to dams, dikes, embankments.
Damage severe to well-built wooden structures and bridges, some destroyed.
Developed dangerous cracks in excellent brick walls.
Destroyed most masonry and frame structures, also their foundations.
Bent railroad rails slightly.
Tore apart, or crushed endwise, pipe lines buried in earth.
Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI. Disturbances in ground many and widespread, varying with ground material.
Broad fissures, earth slumps, and land slips in soft, wet ground.
Ejected water in large amount charged with sand and mud.
Caused sea-waves (tidal waves) of significant magnitude.
Damage severe to wood-frame structures, especially near shock centers.
Great to dams, dikes, embankments, often for long distances.
Few, if any (masonry), structures remained standing.
Destroyed large well-built bridges by the wrecking of supporting piers, or pillars.
Affected yielding wooden bridges less.
Bent railroad rails greatly, and thrust them endwise.
Put pipe lines buried in earth completely out of service.

XII. Damage total—practically all works of construction damaged greatly or destroyed.
Disturbances in ground great and varied, numerous shearing cracks.
Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive.
Wrenched loose, tore off, large rock masses.
Fault slips in firm rock, with notable horizontal and vertical offset displacements.
Water channels, surface and underground, disturbed and modified greatly.
Dammed lakes, produced waterfalls, deflected rivers, etc.
Waves seen on ground surfaces (actually seen, probably, in some cases).
Distorted lines of sight and level.
Threw objects upward into the air.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

(Abridged)

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognise it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars.

IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

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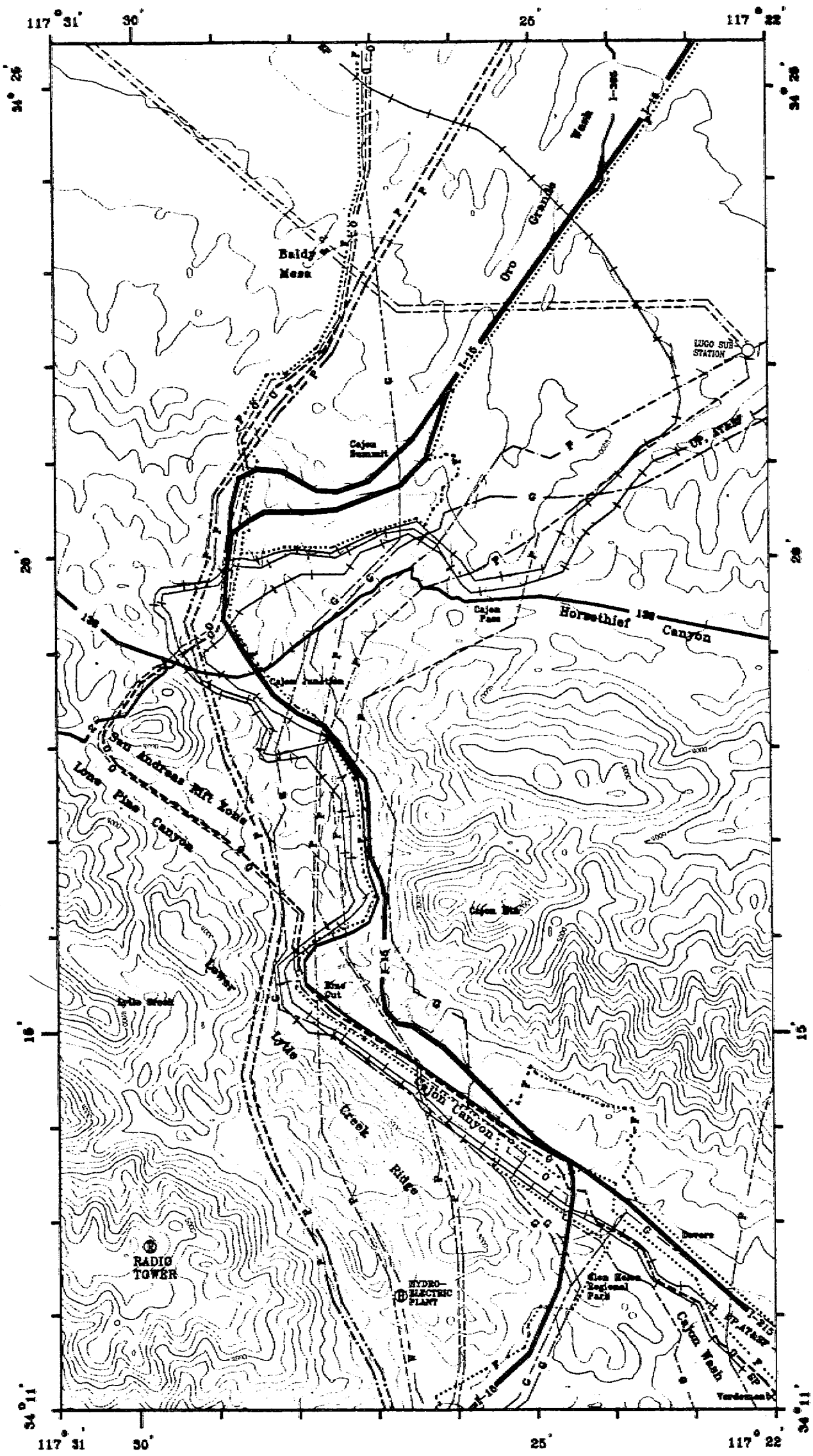

FIGURE 6, A COMPOSITE OF THE LIFELINE ROUTES AT CAJON PASS

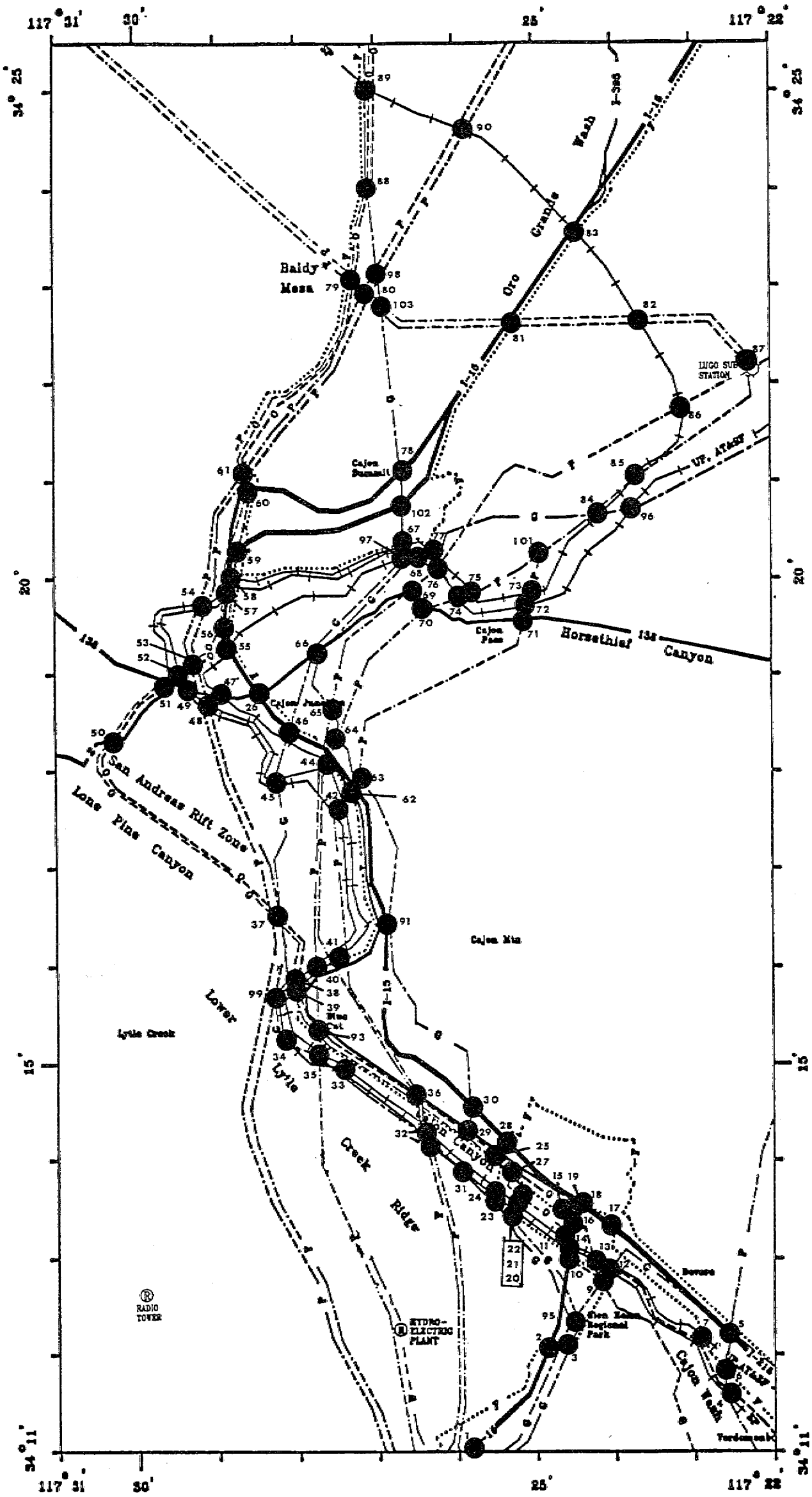

FIGURE 7, IDENTIFICATION OF LIFELINE COLLOCATIONS AT CAJON PASS

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

- I-15 — INTERSTATE
- 2 — PAVED HIGHWAY
- COLLOCATION LOCATION
- RAILROAD
- P — POWER LINES
- O — PETROLEUM PRODUCT PIPELINES
- G — NATURAL GAS PIPELINES
- F — FIBER OPTIC CABLE
- W — FLUME-PENSTOCK

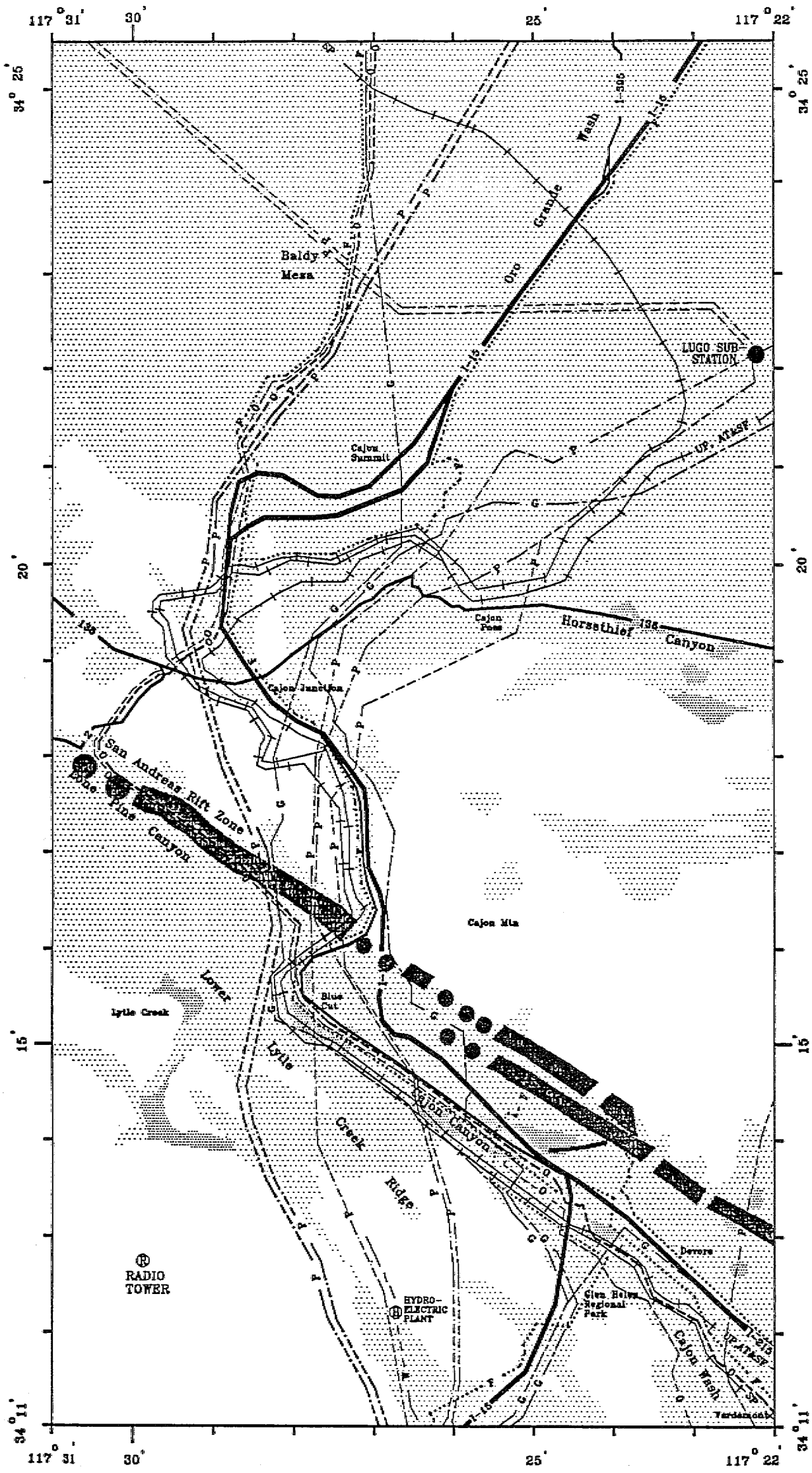

FIGURE 8, LIFELINE ROUTES WITH SHAKING INTENSITY AND POTENTIAL LANDSLIDE AND LIQUEFACTION AREAS

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

- I-15 — INTERSTATE
- 2 — PAVED HIGHWAY
- RAILROAD
- P — POWER LINES
- W — FLUME-PENSTOCK
- O — PETROLEUM PRODUCT PIPELINES
- G — NATURAL GAS PIPELINES
- F — FIBER OPTIC CABLE

MODIFIED MERCALI SHAKING INTENSITY

VIII+ | VIII | VII | VI

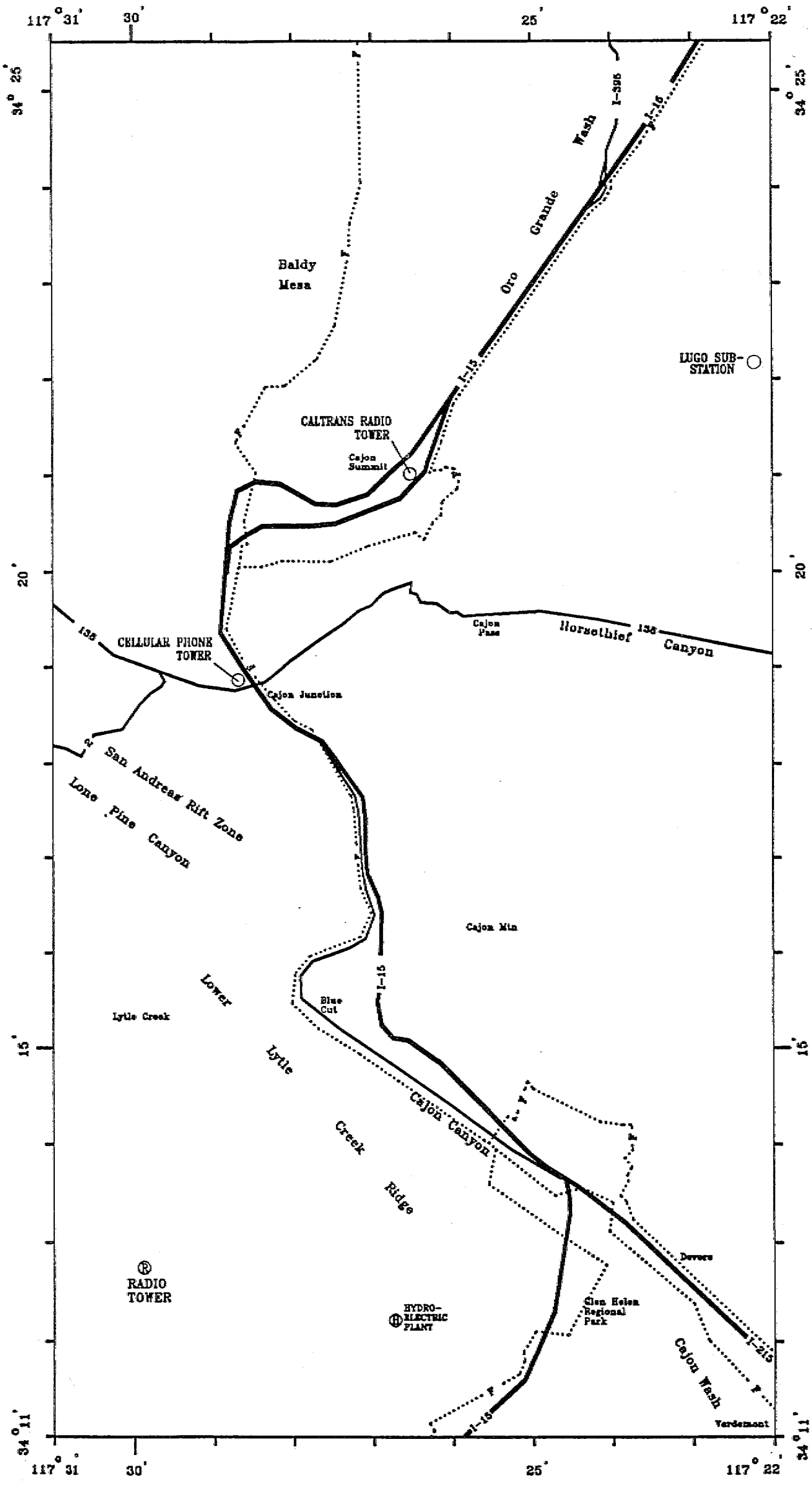

FIGURE 9, COMMUNICATION LIFELINE ROUTES

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

I-15 INTERSTATE

2 PAVED HIGHWAY

F F FIBER OPTIC CABLE

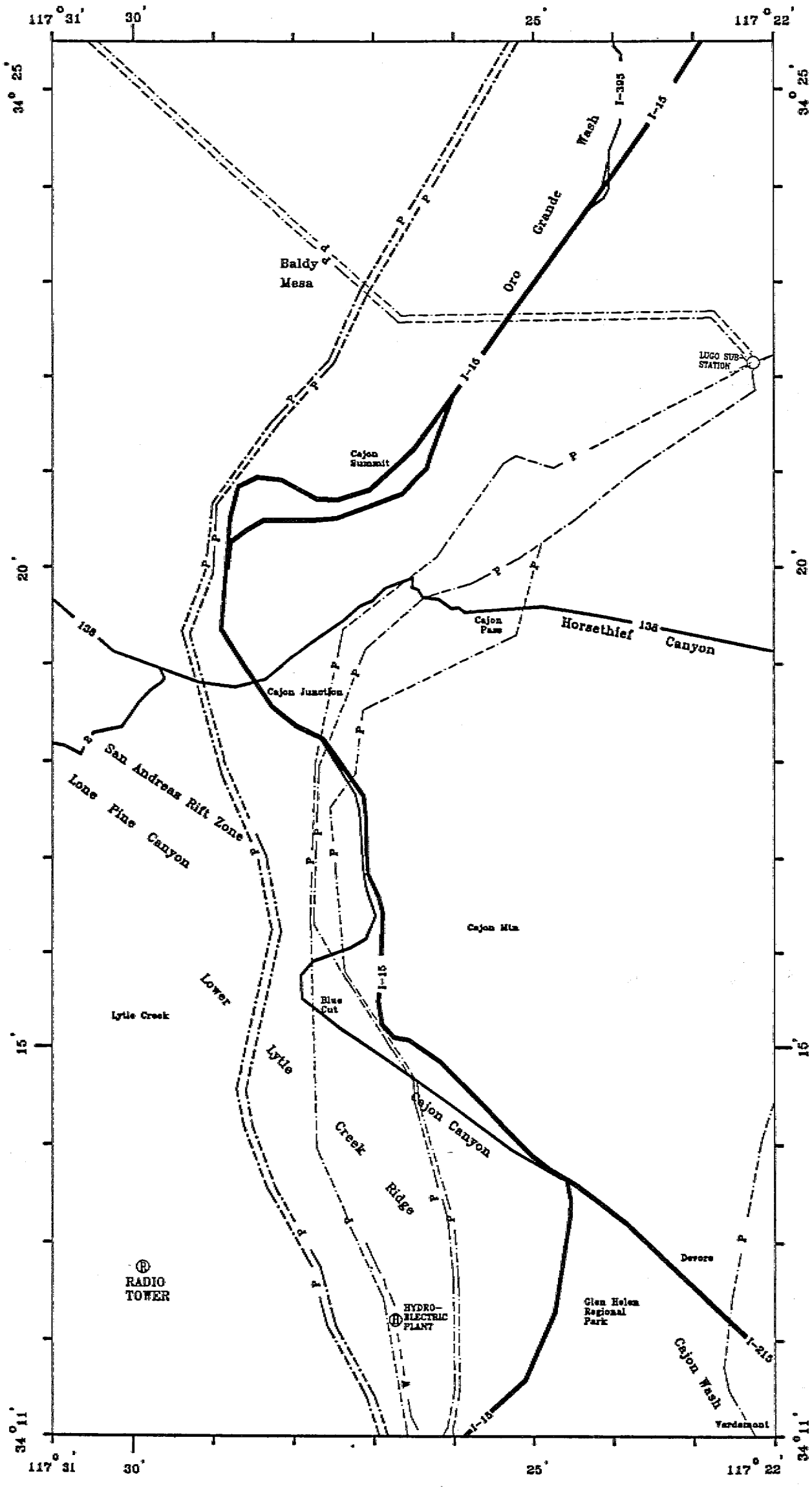

FIGURE 16, ELECTRIC POWER LIFELINE ROUTES

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

I-15 INTERSTATE

2 PAVED HIGHWAY

P P POWER LINES

W W BURIED AQUEDUCT

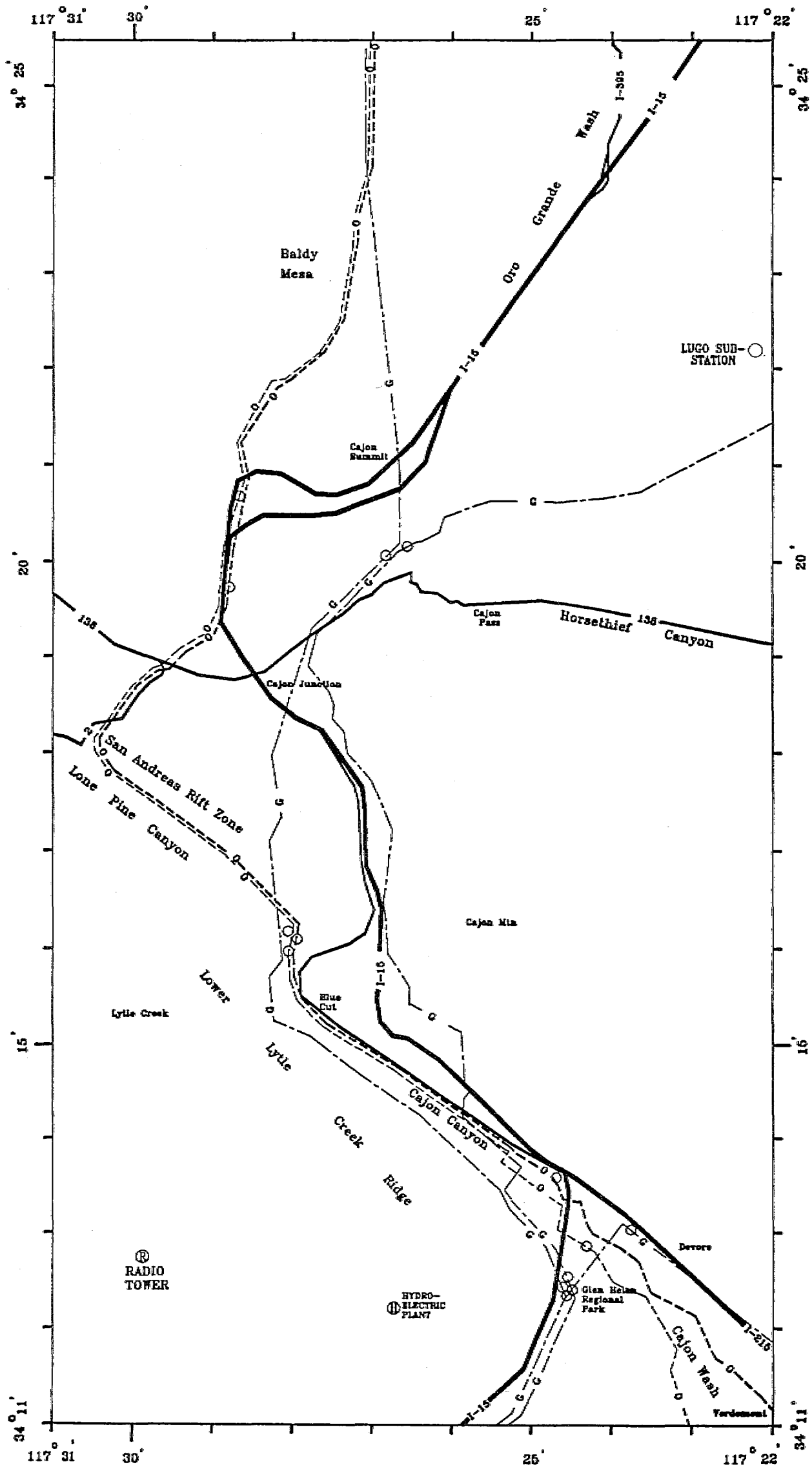

FIGURE 20, FUEL PIPELINE LIFELINE ROUTES

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

I-15 INTERSTATE

2 PAVED HIGHWAY

O PETROLEUM PRODUCT PIPELINES

G NATURAL GAS PIPELINES

VALVES

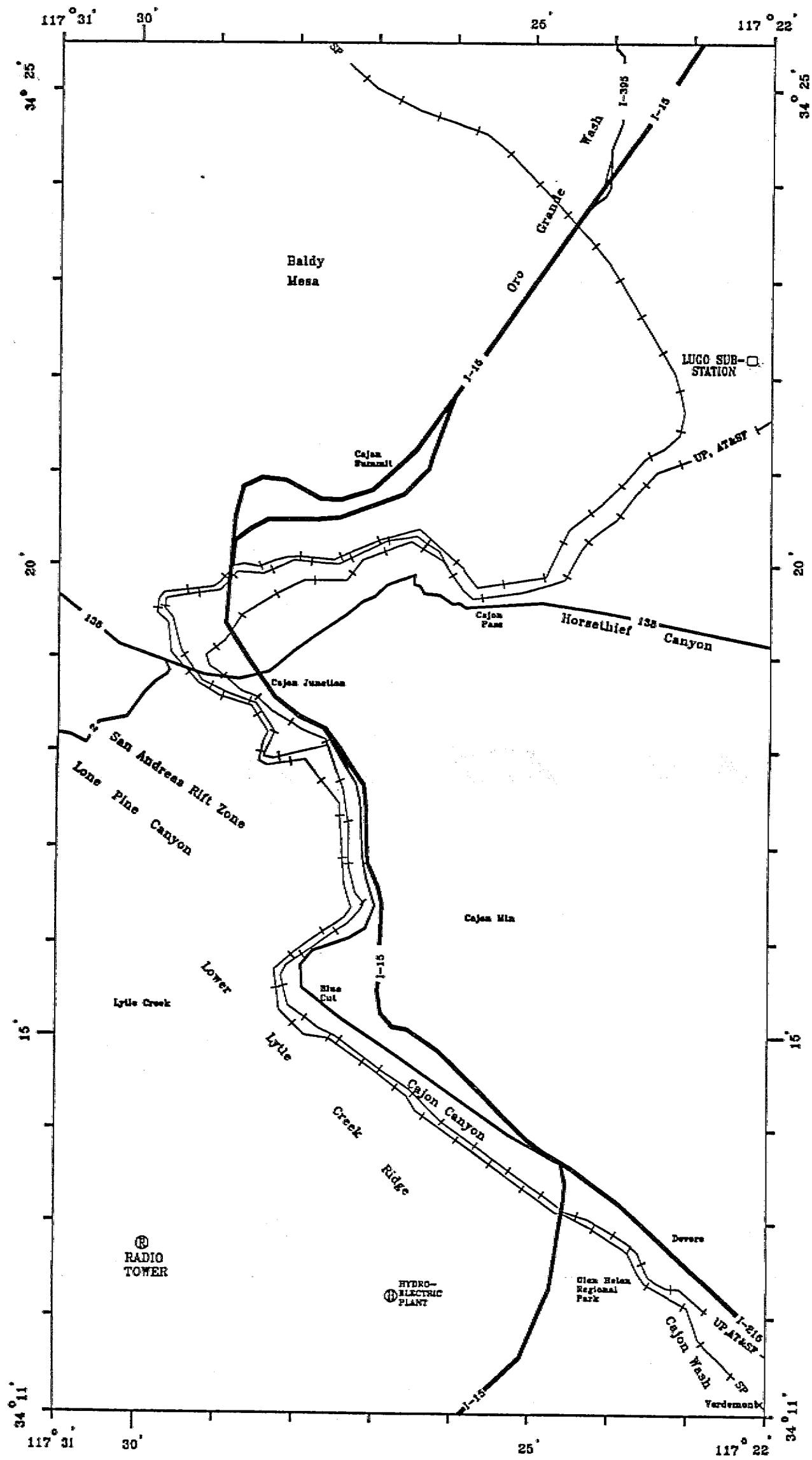

FIGURE 24, TRANSPORTATION LIFELINE ROUTES

SCALE

0 1 2 MILES

0 1 2 KILOMETERS

N

EXPLANATION

I-15 INTERSTATE

2 PAVED HIGHWAY

RAILROAD